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STUDY INTO THE EFFECT OF IMPURITIES ON THE SURFACE TENSION OF IRON MELTS

by

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The influence of Sn, Al, Cu, Ti, Sb, Bi, As, Pb, and Ce on the surface tension of pure Fe-C-Si melts of hypo- and hypereutectic point compns. has been investigated. The expts. were carried out at 1500 degrees in He atm. Sn, Al, Cu, Bi, Sb, As, Pb, and Ce are surface active in the Fe-C-Si melts whereas Ti is inactive. The surface activity of these elements is 1.5 times higher in the hypoeutectic point melts than in the hypereutectic point melts.

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	ROLE	WT	ROLE	WT	ROLE	WT
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Copper						
Thalium						
Arsenic						
Bismuth						
Cerium						
Antimony						
Lead						

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Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

STUDY INTO THE EFFECT OF IMPURITIES ON THE SURFACE TENSION OF IRON MELTS

L. I. Levi and S. A. Gladyshev

The structure and properties of metals and alloys in cast items depend on numerous factors, among which a major - if not a decisive - role is played by the liquid state. On the basis of an analysis of the structural properties of metal melts, specifically cast irons, from the standpoint of colloidal chemistry is has been possible to establish that Fe—C—Si alloys with high carbon content represent a colloidal-type nonequilibrium microheterogeneous system with an enormous interface and, consequently, with a large store of surface energy [1, 2]. As a result, the presence in the melt of even thousandths of a percent of surface-active impurities may exert a substantial effect on the structure and properties of the melt, as well as on the modification and crystallization processes, so as to determine the quality of the castings obtained.

Of particular importance to the production of cast iron with spherical graphite are such admixtures as Ti, Bi, Sb, As, and others. Their presence in the melt hinders, and occasionally altogether excludes, the acquisition of spherically shaped graphite [1, 3-5]. The degree of globularization is related to the impurity quantity. Although increasing the amount of magnesium introduced improves somewhat the globularization conditions, the required results are

forthcoming only in the event the sum of the microimpurities does not exceed 0.2% [4]. Of interest is the fact that when they are jointly present in the cast iron, the deleterious effect of such impurities as Ti, As, Sn, Al, Sb is intensified. While in the absence of other elements titanium in the amount of 0.1% has no negative effect on the formation of globular graphite, in the presence of very small amounts of Sn, Pb, and Bi it has a marked influence at a concentration of even 0.08% [5]. The mechanism of the antiglobularizing effect of microimpurities is not clear. In [6] the effect of Pb and Bi is explained by the increased content in the cast iron of gases, especially of oxygen, which leads to a lessening of the surface tension of the melts. The negative effect of oxygen on the globularization of graphite is also noted in references [4, 5]; however, no quantitative dependence has been established. It is possible that the effect of the deglobularizing elements is associated with the development of modifier-demodifier compounds or else with impeded modifier adsorption on the graphite inclusions.

Using the method of maximum pressure in a gas bubble, a study was made of the individual effect of Sn, Al, Cu, Ti, Sb, Bi, As, and Pb on the surface tension (σ, dyn/cm) of pure Fe—C—Si alloys of hypo- and hyper-eutectic composition, as well as the effect of Ce on the surface tension of pure Fe—C—Si alloys and alloys containing demodifier elements. The Fe—C—Si alloys were produced by melting in an atmosphere of helium (VCh grade)[1] at a pressure of 0.1 atm abs of class V-3 carbonyl iron (grade "particularly pure"), semiconductor silicon, and 99.999 pure graphite. The iron was additionally remelted in a vacuum at a vacuum pressure of $1 \cdot 10^{-5}$ mm Hg in alundum crucibles. The chemical composition of the test alloys is indicated below.

[1][Translator's Note: The letters "VCh" may stand for the Russian "vysokoy chistoty" = "high purity."]

(1) Сплавы доэвтектические	(2) Шифр сплава	(3) Сплавы заэвтектические	(2) Шифр сплава
Fe—C—Si	A	Fe—C—Si	B
Fe—C—Si+0,1% Sn	1	Fe—C—Si+0,3% Sn	1
Fe—C—Si+0,1% Al	2	Fe—C—Si+0,1% Al	2
Fe—C—Si+0,5% Cu	3	Fe—C—Si+0,5% Cu	3
Fe—C—Si+0,3% Ti	4	Fe—C—Si+0,5% Ti	4
Fe—C—Si+0,1% Bi	6	Fe—C—Si+0,1% Bi	5
Fe—C—Si+0,1% Sb	5	Fe—C—Si+0,1% Sb	6
Fe—C—Si+0,1% As	7	Fe—C—Si+0,1% As	7
Fe—C—Si+0,1% Pb	8	Fe—C—Si+0,1% Pb	8

Note: Element content in the hypoeutectic alloys: 3 5% C, 1.0% Si, remainder Fe. Element content in the hypereutectic alloys: 3.5% C, 3.3% Si, remainder Fe.

KEY: (1) Hypoeutectic alloys; (2) Alloy No; (3) Hypereutectic alloys.

The apparatus and the methodology of surface-tension measurement have been described in detail in reference [7]. The measurements were conducted at a temperature of 1500°C in an atmosphere of grade VCh helium. Zone-melted "particularly pure" elements along with 98% cerium were employed as admixtures. The established surface activity (dyn/cm) relations with the introduction of 1% of a surface-active element in Fe—C—Si alloys (concentration 0.1%) have the following values:

Alloy	Type alloy	Sn	Al	Cu	Ti	Bi	Sb	As	Pb	Ce
Fe—C—Si	A	1420	832	360	0	4636	3000	1400	2740	1795
Fe—C—Si	B	1010	—	840	0	2896	2200	1060	1544	980

Such elements as Sn, Cu, Bi, Sb, As, and Pb are surface-active in both hypo- and hyper-eutectic Fe—C—Si alloys (Fig. 1). Titanium, is inactive. Aluminum is surface-active in the hypoeutectic alloy. The increase in surface tension accompanying the introduction of 0.001% Al in the hypereutectic alloy is evidently caused by the binding of the oxygen residue. From the data presented it is clear that for all the tested elements, with the exception of copper, the magnitude of surface activity in the hypoeutectic alloy is approximately 1.5 times greater than in the hypereutectic. This is

evidently related to the higher silicon content in the hypereutectic alloy, preventing the concentration of other elements on the interface surface.

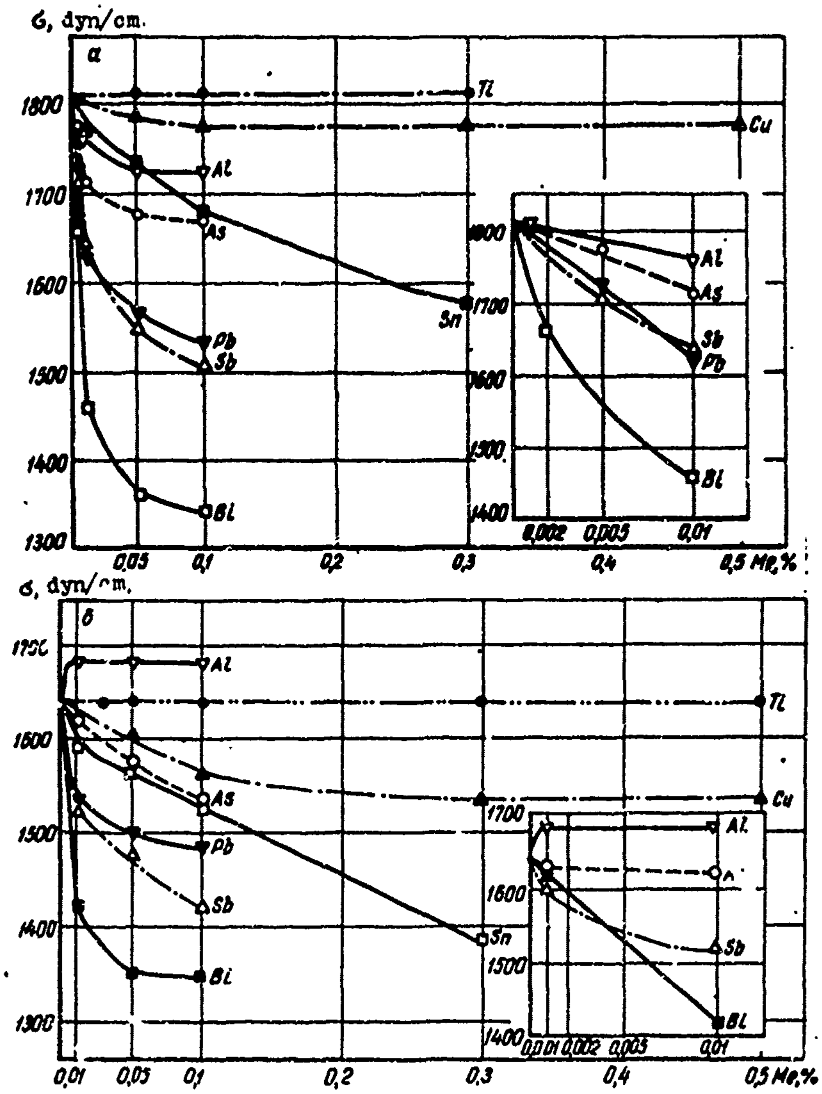

Fig. 1. Effect of deglobularizing elements on the surface tension of Fe—C—Si alloys of hypoeutectic A (a) and hypereutectic B (b) composition.

Studies of the effect of cerium on the surface tension of Fe–C–Si alloys indicated that this is a surface-active element in both pure alloys (Fig. 2) and in alloys containing deglobularizing elements (Fig. 3). In the hypoeutectic Fe–C–Si alloy, with the addition of 0.3% Ti, surface tension remains unchanged up to a 0.2% Ce content; with the cerium content further increased, surface tension falls off (Fig. 3). In the hypereutectic Fe–C–Si alloy, with 0.5% Ti added, the surface tension remains constant even in the face of a 0.3% Ce concentration. It is probable that Ti has the effect of neutralizing the cerium, preventing it from concentrating in the surface layers. In amounts exceeding the effect of the titanium, the cerium acts as a surface-active element. The surface activity of serium in hypoeutectic alloys is higher than that of Al, Ti, Cu, As, and Sn; in the hypereutectic alloys it is lower and exceeds only Al, Ti, and Cu.

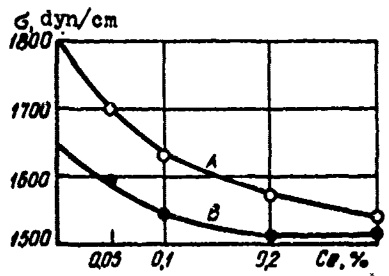

Fig. 2. Effect of cerium on the surface tension of hypo- and hyper-eutectic Fe–C–Si alloys.

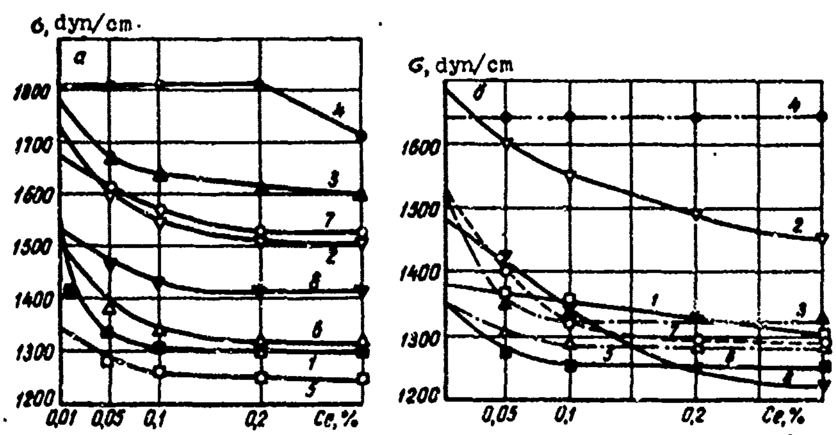

Fig. 3. Effect of cerium on the surface tension of hypoeutectic (a) and hypereutectic (b) Fe–C–Si alloys with deglobularizing element admixtures.

It was established that the elements Sn, Al, Cu, Bi, Sb, As, Pb, and Ce are surface-active in Fe—C—Si alloys, with their surface activity approximately 1.5 times greater in hypoeutectic alloys than in hypereutectic. Titanium is inactive.

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